Enhancing Water Supplies In The Flint River Basin: A Preliminary Exploration Of The ASR Alternative*

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by

Douglas Wilson and Ronald Cummings
Georgia Water Planning And Policy Center

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Abstract

This study represents the first of a multi-stage project for assessing the physical and economic feasibility of using Aquifer Storage and Recovery (ASR) technology as a means for offsetting water use by new industry in Southwest Georgia. Water quantity in the Flint River Basin is a critically important issue. As a result of water scarcity, the Georgia Environmental Protection Division (EPD) may decide to permanently cap water use permits in the Basin at present levels. This very preliminary exploration of the potential use of ASR technology suggests considerable promise for this technology to serve as a means for enhancing water supplies for municipal and industrial (M&I) uses in the Flint River Basin. Our findings should, at a minimum, serve to stimulate interest on the part of local governments in Southwest Georgia in the possibility of establishing a Regional Authority that manages an ASR system that would provide a means by which the region can take its water future in its own hands. Growth, as it relates to access to water, would be locally controlled. The viability of the use of ASR technology must be decided by a regional authority whose decisions will be guided not solely by direct system costs but also by considerations related to the benefits of allowing for the region to accommodate the water needs of new industry and business. In this regard, consideration of such things as job creation and impacts on local tax bases will be of primary importance. The second phase of our ASR research will shed more light on these issues.

In this report, we also consider the potential feasibility of using ASR technology to offset agricultural water use. Our preliminary findings in this regard are much less promising in strict economic terms than those related to M&I uses. However, further analyses of long-term social benefits associated with accumulated aquifer storage could change these results. Analyses of these and related topics will be forthcoming in the second phase of this research.

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I. Introduction

Aquifer storage and recovery (ASR) is being increasingly used in the United States to achieve two primary objectives: store water in the ground; and recover the stored water for beneficial use. In 1999, there were more than 130 ASR wells operating in the U.S., excluding the 200-plus wells planned for Florida's Everglades Restoration Project (see Figures 1 and 2) .[1] Fifty five of these operating wells were in Georgia's sister state South Carolina. Typically, ASR wells are found in areas that have high population density and proximity to intensive agriculture, dependence and increasing demand on ground water for drinking water and agriculture, and/or limited ground or surface water availability.[2]

The essence of ASR is fairly simple. Water, in the form of potable drinking water from a water treatment plant, ground water (treated or untreated), or surface water (treated or untreated), is injected into a host aquifer *via* a well or an infiltration system (e.g., spreading basins, infiltration galleries, and/or vadose zone recharge wells). It can be recovered later when needed for beneficial use. Water is typically injected during times when water supplies are plentiful and recovered during drought or water-short periods.

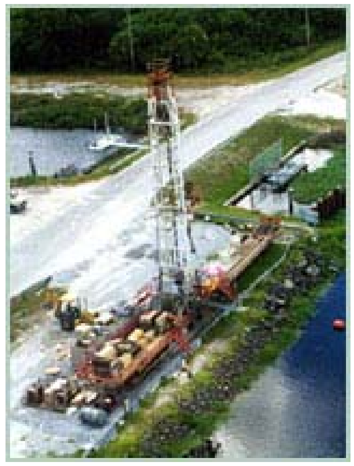
In the Flint River Basin, water scarcity concerns create a real possibility that the Georgia Environmental Protection Division (EPD) may cap the number of water use permits (and associated levels of water use) in the Basin at existing levels. The region is faced with a

[1] U.S. Environmental Protection Agency, *The Class V Underground Injection Control Study, Vol. 21: Aquifer Recharge and Aquifer Storage and Recovery Wells*, Office of Ground Water and Drinking Water, EPA/816-R-99-014u, September, 1999, at p. 2.

[2] *Ibid* at p. 1.

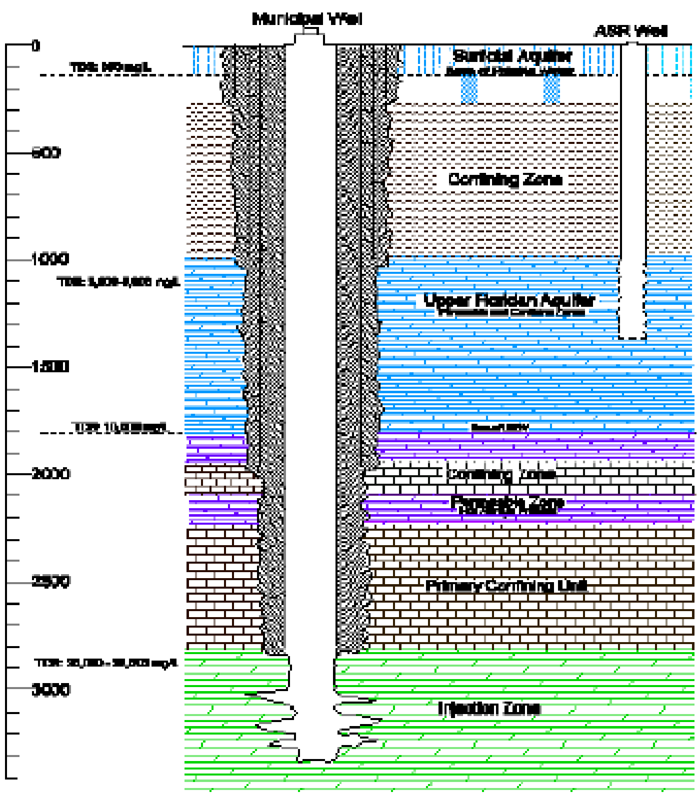
complex

Figure 1
An ASR Well In Florida's Central and Southern Florida Project (CFPR)



Source: *CERP Aquifer Storage and Recovry Program*, available at an. www.evergaldespl org/facts_info/sywt kma_asr.cfm

Figure 2
TYPICAL DEEP-UNDERGROUND INJECTION WELL AND ASR WELL IN SOUTH FLORIDA



Source: *CERP Aquifer Storage and Recovry Program*, available at www.evergaldesplan.org/facts_info/sywtkma_asr.cfm

problem: how can water be made available to accommodate new, future opportunities for population and economic growth? One response to this question is voluntary or involuntary transfers of existing water use permits to new, higher valued uses as they arise in the future.[3] Another response might involve the pooling of any excess water use permits held by communities in the Basin, and their use by water-short communities that encounter growth opportunities. Other alternatives include measures designed to enhance water supplies during periods of drought, such as the construction of reservoirs or the use of ASR.

The purpose of this paper is to explore the feasibility of using ASR technology as a means for enhancing the supply of water in the Flint River Basin during periods of drought.[4] To this end, we begin in Section II with a brief discussion of potential problems and limitations associated with the present state-of-the-art for ASR technology, and comment on their potential relevance for Southwest Georgia. In Section III we consider the potential costs and benefits that might attend the use of ASR in providing water supplies that communities in Southwest Georgia might rely upon as a source of water for new businesses and industry, as well as for accommodating population growth. In Section IV we consider ASR as a possible alternative to

[3] For related discussions, see Young, Robert A., "Why Are There so Few Transactions among Water users?" *Amer. J. Agricultural Econ*., p. 1144, December, 1986.

[4] A bill passed by the Georgia legislature in 2003 prohibits the injection of any surface water into the Floridan aquifer "...in any county governed by the Georgia Coastal Zone Management Program." (Ga. Code at 12-5-135; 12-5-327). Thus, the prohibition is seemingly limited to the coastal area. See the more general endorsement of ASR by the Georgia Environmental Protection Division discussed below.

reliance on the Flint River Drought Protection Act as a means for reducing adverse affects on the Flint River from irrigation during periods of drought. Concluding remarks are offered in Section V.

II. Aquifer Storage and Recovery: A Brief Survey Of Issues

Problems that may be of concern in the consideration of a region's use of ASR technology depend heavily on the source and quality of water to be stored and the hydrogeological characteristics of the host aquifer. In general, four classes of issues appear to be of primary concern: potential contamination of the aquifer; potential leaching of metals from limestone into the recovered water or the surrounding aquifer; degraded water quality in the aquifer that might affect the potential future use of the resource; and the volume of stored water that can be recovered (the percent of stored water that is recovered is referred to as TSV).[5]

Aquifer contamination issues, such as the fate and transport of bacterial, viral, and protozoan pathogens during ASR operations,[6] can be important in settings where untreated water is to be injected into a host aquifer. However, studies have shown that contamination is not a problem when states impose regulations requiring the treatment of injected water to drinking water standards. Florida requires such treatment of injected water.[7] More generally, while such contamination is *possible* if untreated water is injected, the U.S. EPA reports that "No contamination incidents associated with the operation of aquifer recharge or ASR wells have

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[5] For a general discussion of ASR concerns, see Goodwin, Carl R., "Feasibility of Regional-Scale Aquifer Storage and Recovery: Scientific Uncertainties," USGS Open file report 02-09, 2002, and U.S. EPA, 1999, *Op. Cit.*.

[6] See Metge, David, "Fate and transport of bacterial, viral, and protozoan pathogens during ASR operations — What microorganisms do we need to worry about and why?" U.S. Geological Survey, http://water.usgs.gov/orw/pubs/ofr0289/dm_fatetransport.htm.

[7] St. Johns River Waste Management District, "Aquifer Storage and Recovery Issues and Concepts," position paper dated September 15, 2004.

been reported."[8] If Georgia chooses to seriously consider ASR, the contamination issue can be revisited. However, for our purposes we devote no more attention to it given that all scenarios that we consider are based on the presumption (as provided by Georgia's UIC rules discussed below) that water taken from the Flint River for ASR storage will be treated to drinking water standards.

Low concentrations of metals and radionuclides may occur naturally in the materials that form the host aquifer. This occurs particularly when the aquifer consists of limestone as is the case in many Florida aquifers. Given the typical higher oxidation-reduction potential (Eh) of treated surface water, metals (such as arsenic, uranium, or mercury) have been found at elevated concentration levels during *initial* cycle testing at ASR sites in Florida.[9] However, metal concentrations have been found to decline with time, distance from the ASR well, and successive operating cycles. No long-term operating ASR site in Florida is known to have elevated concentrations of metals. Based on testing and operational experience at 13 ASR well fields in Florida that have been in operation for up to 21 years, it is anticipated that metal concentrations should subside to acceptable levels after four to eight operation cycles. Thus, before ASR water is used for drinking water supply, the system could be operated through a number of trial cycles, with continual testing for metal concentrations[10]. Existing research offers considerable promise for ASR systems to ultimately offer high quality drinking water. Indeed, a recent study of ASR by the Georgia EPD indicates that such impacts on the aquifer can be mitigated by proper siting,

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[8] U.S. EPA, 1999, *Op. Cit.* at p. 2.

[9] St. Johns River Waste Management District, *Op. Cit*. 2004, at p. 2.

[10] *Ibid.*

testing, and modifications to design and/or operations.[11]

Pathogenic microbiota are not present in the treated recharge water used in Florida. More generally, scientific investigations to date have shown that bacteria, viruses, and some protozoa attenuate naturally and rapidly during ASR storage.[12] This natural attenuation serves as an additional barrier to protect ground water quality and public health.[13] Again, appropriately treated injected water appears to minimize potential problems associated with aquifer contamination. We note that Georgia's Underground Injection Control (UIC) rules, promulgated under O.C.G.A. 12-5-20, are quite stringent in terms of efforts to protect public health and safety. Among other things, Georgia's UIC rules prohibits the injection of ASR water that does not meet drinking water standards.

The "recovery efficiency" of an ASR well (i.e., TSV) is determined in large part by the volume of water needed in the buffer zone separating the storage "bubble" from the native water in the aquifer. If surrounding native water is high quality, the buffer zone can be quite small; if it is low quality, the buffer zone needs to be very high.[14] One would expect that TSV would be quite high in the Flint River Basin given that water quality in aquifers that could serve as host aquifers (e.g., the Clayton and/or Claiborne aquifers) have high quality water. Even in the *brackish* aquifers used for storage in Florida, TSV starts out low but improves with successive operating cycles due to freshening of the storage zone around an ASR well. According to a report from the St. Johns Water Management District on ASR, "Virtually all of the ASR wells

[11] Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, "Assessment of Environmental Effects Associated With Potential Aquifer Storage Recovery Projects In Coastal Georgia," Project Report 44 (Atlanta: 2001).

[12] St. Johns River Waste Management District, *Op. Cit*. 2004.

[13] Georgia EPD, 2001, *Op. Cit*.

[14] Aquifer Storage Recover Forum at www.asrforum.com.

that have been operating for more than five years have reached acceptable and economically viable levels of recovery efficiency."[15]

In general, the observations and conclusions noted above are echoed in a Georgia EPD report published in 2001. Conclusions offered in this study were as follows.[16]

> "Experience during the past 17 years with ASR development in other states has shown that initial uncertainties, such as the questions poised in this memorandum (the CH2MHill Assessment) are relatively normal...Full confidence in the applicability of ASR technology in Georgia can only come from having at least one full size ASR well constructed, tested, permitted and placed in operation. Until that time arrives, partial confidence can be achieved through literature reviews, studies, investigations, modeling, and site visits to other nearby operating ASR sites utilizing the upper or lower zones of the Floridan Aquifer as a storage zone."

> "In summary, ASR has the potential to be a useful water resource management tool in coastal Georgia. Some concerns have been identified, but no environmental impacts have been identified that could not potentially be mitigated. An active permit program administered by GAEPD could insure that pre-construction investigations, pilot testing, and ASR design, operation, and monitoring are adequate to achieve the water resource management benefits while mitigating environmental impacts."

The EPD report notes that the conclusions of experts performing peer reviews of the EPD ASR study indicate that inherent adverse environmental impacts associated with a properly designed and operated ASR system could not be identified. The EPD "...recommends that coastal Georgia stakeholders seriously consider ASR **as an environmentally sound approach to enhance the water supply options of (sic) region**."[17] (Emphasis added)

With this endorsement by the Georgia EPD in mind — an endorsement that applies to the arguably more difficult circumstances found in coastal Georgia — attention is now turned to

[15] St. Johns River Waste Management District, 2004, at pp. 2 and 3.

[16] Georgia EPD, 2001, *Op. Cit.*.

[17] *Ibid.*

exploration of specific applications of ASR technology that might be considered in the Flint River Basin.

III. Using ASR To Provide Water For Future M&I Uses In The Flint River Basin

Communities in Southwest Georgia could use ASR technology in a number of ways to provide water supplies for new industry and economic growth. Given uncertainty about the amount of time required to accomplish appropriate tests and trial cycles of an ASR system before it could be put into use, if interest in pursuing ASR exists, it would be prudent to begin to develop some level of ASR capacity so that it would be available to communities if and when economic opportunities arise which require access to new water use permits.

ASR potentially offers local governments in the region the opportunity to take their "water future" *into their own hands* — to manage water in the way that they believe best serves the region's interests. To this end, we suggest one of many *possible* approaches that might serve this purpose: a regional ASR authority. Our intention is not to advocate this or any other approach. Our intention is simply to set out an alternative that water managers in Southwest Georgia might take as a point of departure in thinking through ways by which ASR technology might be used to avoid limitations on economic growth posed by water shortages during periods of drought.

A. A Regional ASR Authority.

A regional ASR authority would comprise officials from counties and/or communities in the basin that choose to participate. The initial charge of the Authority would be the following:

1. The Authority would negotiate an agreement with the EPD wherein the EPD agrees to issue

new water use permits to new business/industry wishing to locate within the Authority's jurisdiction <u>under the condition</u> that the Authority will offset, during periods of drought, any new water use associated with these permits from ASR storage. An important aspect of these negotiations would be a definition of conditions constituting "drought conditions" during which offsets would be required.

2. If a period of drought occurs during the interim period between the initiation of any newly permitted water use and the initiation of operation *of an EPD-<u>approved</u>* ASR storage facility, the Authority would agree to offset the new water use through the lease of agricultural water use from farmers qualified to participate in the Flint River Drought Protection auction. It would be prudent for the Authority to negotiate "futures" leasing arrangements with farmers in the area.

3. The Authority would acquire land in appropriate areas and conduct initial testing required by the EPD for approval of an ASR site. Such testing might include the design of the required water treatment plant (approved by the EPD) as well as any other system elements. Investment for the actual construction of any treatment plants as well as the development of production wells could be deferred until the need for offset water becomes a reality. Thus, plans for the ASR system are in place and approved by the EPD. It may or may not be desirable to put the full scaled wells and/or treatment plants in place prior to their need.

One of the advantages of ASR is that discharge capacity can be built in relatively small increments. ASR well systems with a capacity of around 5 mgd (involving 2 to 3 production wells) are common in Florida.[18] This capacity is more than sufficient to satisfy all but the largest

[18] See St. Johns River Waste Management District, 2004, *Op. Cit.*

water using industries (e.g., paper mills).[19] ASR well systems with much larger capacity are being used in the U.S..[20] Capacity can be established based on the current size of a developed system or by sequentially adding smaller-scaled wells as demand for water increases. With relatively small-scaled ASR systems (i.e., on the order of 5 mgd with a treatment plant with a capacity of 10 mgd, which could serve a well system with a 50 mgd capacity)[21] the system can be expanded by the addition of new wells and, perhaps, treatment capacity, only as the need for such expansion arises.

Given a regional authority that is pursuing the establishment of an ASR system, communities in the Flint River Basin can advertise to the business community: Locate in the Flint River Basin -- we have more than ample water supplies to fill your needs. The costs of taking the steps described above to develop a regional authority and be prepared for possible future economic opportunities should be nominal. One would expect that these costs would certainly be small relative to the potential gain for the region.

B. Preliminary Estimates for the Design, Construction, and Operation of an ASR System.

In this sub-section we provide *very* tentative and rough estimates for the cost of an ASR system for the Flint River Basin such as that described above. Detailed engineering plans and more definitive benefit/cost estimates will be provided in the second phase of our work, which is

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[19] See Cummings, *et al.* "Industrial Water Use/Discharge Statistics," Water Policy Working Paper #2003-009, Georgia Water Planning and Policy Center, May, 2003.

[20] Several wells in the Phoenix, Arizona area have capacities in excess of 100,000 acre feet. See "Alternative: Aquifer Storage and Recovery," Jemez y Sangre Water Plan, Alternatives Assessment," White Paper, July 2002, at p:/9419/White Papers.7-2002/PDF/JIC/12_AquiferStrg-Recvry_TF.doc.

[21] Smaller treatment plants could be constructed, but in our judgement economies of scale make a 10 mgd plant the smallest feasible size.

planned for FY '06. The intended purpose of this report is to provide decision makers in the region with a basis on which initial discussions concerning their interest in the possibility of forming an ASR Regional Authority might be based. The appropriate context within which data provided in this report might be used is discussed in more detail below.

Our preliminary cost estimates for an ASR system in Southwest Georgia are based on the following assumptions.

<u>Assumption #1</u> After completing negotiations with the EPD, as described above, the Authority would prepare initial plans for the ASR system, conduct appropriate testing of aquifer characteristics as required by the EPD, and obtain the UIC permit. We assume costs for these activities to be $250,000. We assume that land for the ASR system would be public land located adjacent to Lake Chehaw (Lake Worth), a 1,400 acre impoundment of the Flint River, Muckalee and Kinchafoonee creeks. The reservoir is owned and operated by the Georgia Power Company. We assume that land-associated costs are $50,000. At this point, the Authority would be prepared to initiate the development of an ASR system when the demand for new water permits, with attendant economic opportunities for the region, arise.

<u>Assumption #2</u> At the point in time when a new industry is committed to locate in the region, thereby requiring an Authority-sponsored water use permit, the Authority would initiate construction of a treatment plant and the required number of ASR production wells. Costs associated with these activities depend, of course, on the water requirements of the new industry. For present purposes, we assume that the new industry requires between 1 and 5 mgd. Thus, the Authority would initiate construction of an appropriately-sized treatment plant (assumed to be 10 mgd, which has a capacity of 50 mgd and could thus accomodate later expansions in the number

of ASR wells) and two production wells. The initial capital cost for the treatment plant is assumed to be $10 million, and the plant is assumed to have a useful life of 20 years. Costs for the two production wells that would provide a production capacity of up to 5 mgd are assumed to be $400,000 each (i.e., a total cost of $800,000). Wells are assumed to have a 50 year useful life. Annual operation and maintenance (O&M) costs for the treatment plant and wells are assumed to be $1 million (10% of capital cost) and $40,000 (5% of capital cost), respectively. The present value (as of the date that construction is initiated) of these O&M costs over 20 years using a 5% discount rate would be $13.3 million.

Given these cost assumptions, the annual cost required to pay all capital costs over 20 years, plus the present value of all O&M costs over 20 years, would range from $1.04 per 1,000 gallons and $5.21 per 1,000 gallons depending on whether the new industry(industries) used 5 mgd or 1 mgd, respectively, over the 20-year time period.

<u>C. ASR Feasibility and Implementation.</u>

Given the above cost estimates, the economic feasibility of establishing an ASR system would, of course, depend upon the benefits that would accrue to the Southwest Georgia region as a result of the new water uses. Such benefits are economic and, perhaps, non-economic in nature and involve judgements that would be best made by the Regional Authority. At issue in such an assessment are questions such as: how many jobs will the new business or businesses that use the new water permits create; how will the tax base of regional communities be affected; how could the location of these new businesses enhance the ability of Southwest Georgia to attract *still more* new businesses to the region?

If an ASR is established, it is likely that new water uses, particularly in early years, would require much less of an offset during drought years than the capacity of the system. Unused capacity can be used to build up storage supplies during these periods. The build up of storage in the early phase of ASR implementation or in instances where drought periods do not occur for many years would develop a water source that is available to this region and possibly to the rest of the state for an infinite period of time. The social value of such storage may be substantial and may serve as a credible rationale for cost-sharing between the Authority and the State for the development of the ASR system.

IV. Could ASR Serve as an Alternative to the Drought Protection Act?

The Flint River Drought Protection Act[22] provides for the EPD to reduce irrigated acreage in the Lower Flint River Basin during periods of drought by making payments to farmers (via an "auction-like" process) for their temporary suspension of irrigation (April through December of the year in question).[23] During the 2001 and 2002 auctions, approximately 36,000 and 40,000 acres, respectively, were taken out of irrigation by auctions conducted by the EPD. The average price per acre paid by the EPD was approximately $136.00 and $145.00 during the 2001 and 2002 auctions, respectively. If we assume that these temporarily retired lands would have used between 12 and 18 inches of water per acre during the summer irrigation season (40% of which takes place during the month of June), the result of the auctions was to "offset" the effects of agricultural water use on flows in the Flint River by 156 mgd to 235 mgd (2001) and 174 mgd to 234 mgd (2002) during the critical month of June.

At this time, we can do little more than speculate as to the potential for an ASR system to offset agricultural water use during drought. In the second phase of our research, which will take place during FY '06, detailed engineering and economic analyses will provide more concrete analyses. At this point, however, a few observations can be offered. A 50 mgd ASR system could offset, during June, the equivalent of some 11,500 acres. In the 2002 auction, an offset of

[22] O.C.G.A. 12-5-540-550.

[23] See, e.g., Laury, Susan K., "Enhancing and Improving Designs for Auction Mechanisms that can be used by the EPD for Irrigation Auctions," Water Policy Working Paper #2002-012, Georgia Water Planning and Policy Center, September, 2002.

this size would have cost almost $1.7 million -- *for a one-time offset*. Based on our cost estimates, establishing the ASR offset would cost in excess of $25 million, but the offset could be provided almost annually. The economic feasibility of using ASR offsets as a substitute for EPD auction offsets would then depend, of course, on the frequency of drought. For a similar offset, the auction would be costing some $1.7 million per drought year; the ASR offset would involve a one-time cost of some $25 million.

The economic feasibility of an ASR system for this purpose is clearly not as compelling as for the M&I scenario. However, this assessment does not consider any social values that would attend the accumulation of aquifer storage notwithstanding waters retrieved during offset periods. We will consider the value of this storage in the second phase of our ASR research.

V. Concluding Remarks.

This very preliminary exploration of the potential use of ASR technology suggests considerable promise for this technology serving as a means for enhancing water supplies for M&I uses in the Flint River Basin. The establishment of a Regional Authority that would manage the ASR system would provide a means by which, in the face of an EPD-imposed cap on new water use permits, the region can take its water future in its own hands..Growth, as it relates to access to water, would be locally controlled. Our findings should, at a minimum, serve to stimulate discussion by local governments in Southwest Georgia about the possibility of establishing an ASR arrangement as suggested here. In the end, an assessment of the viability of the ASR technology must be made by a Regional Authority whose decisions are guided not only by direct system costs, but also by consideration of the benefits of creating regional capacity to accommodate the water needs of new industry and business. In this regard, consideration of issues including job creation and impacts on local tax bases will be of primary importance. The second phase of our ASR research will address these concerns.

The potential feasibility of using ASR technology to offset agricultural water use in the Flint River Basin is less promising in strict economic terms. However, further analyses of long-term social benefits associated with accumulated aquifer storage could change this assessment. Analyses of these and related topics will be forthcoming in the second phase of our ASR research.